

Challenges of Integrating ICT in Healthcare - A Predictive Analysis

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KEY WORDS	ABSTRACT
ICT Integrating ICT Healthcare m-Health services m-Health adoption challenges Pandemic	The integration of Information and Communication Technologies in the healthcare domain has revealed the emergence of novel innovations like mobile health (m-health) services that have been extensively demanded in the current era. However, the adoption of m-health has encountered various issues, especially in developing countries, which emphasizes the need to address these challenges. Despite the potential of m-health, a comprehensive identification and understanding of issues is required. Therefore, this study aims to propose a hierarchical, predictive model following the identification of the critical challenges for the adoption of m-health practices. An exhaustive list of 49 challenges has been formulated after an intensive literature search. This study, quantitative in nature, has distributed 185 survey questionnaires to gather data from related stakeholders, including healthcare professionals, patients, academicians, and IT professionals. The statistical tools, Cronbach's Alpha, Principal Component Analysis, and Logistic Regression, are applied to analyse the gathered empirical data. Consequently, seventeen challenges, having a greater mean value, have been revealed as the most crucial challenges regarding the adoption of m-health. Based on the CHEATS framework, these extracted challenges have been further categorized into four dimensions. These are educational awareness, supportive infrastructure, technical support, and professional culture. The m-health software quality, medical professional readiness, and poor Internet access have emerged as prominent challenges. The proposed model provides a roadmap to health enforcement agencies for efficient and successful adoption of m-health services. Furthermore, this study may assist users in becoming acquainted with m-health by highlighting its benefits, ultimately leading to the efficient use of m-health applications.

1. Introduction

As digitization continues to elevate, healthcare organizations have started to integrate Information and Communication Technologies (ICT) in response to the growing challenges [1]. The integration of ICT

for the efficient accomplishment of healthcare functions is labelled as digital health, which may comprise electronic health (e-health), mobile health (m-health), or telehealth [2, 3]. According to the World Health Organization (WHO), integrating ICT in health is not merely about technology; instead, it

acts as a gateway to a series of desired outcomes in the complete health domain [4]. Mobile applications are being utilized in healthcare for the administration of patients, monitoring of public health, research, and health education, which is termed as m-health [5-7]. Moreover, m-health encompasses the usage of digital data for professional culture, supportive infrastructure, and educational awareness purposes at local locations and distant places by utilizing smartphones [8, 9]. The m-health has occupied a prime place in society. The existing studies have focused on the importance of m-health and its benefits, leaving a significant gap in understanding the critical issues that may hinder the adoption of m-health.

The m-health has a profound effect on almost every field of daily life, including economics, tourism, construction, manufacturing, education, and health [10]. The latest technological trends are broadening the scope of m-health globally, resulting in the exponential adoption of m-health [11, 12]. The adoption of m-health during the pandemic has provided evidence-based practice for the endorsement of technology that impacts human health [13, 14]. Internet-based telemedicine, asynchronous healthcare communication systems, and electronic health records have been used in healthcare to augment the proficiencies of clinical staff and physicians [15].

The m-health focuses on monitoring various health conditions with the help of digital technologies and is often considered while formulating policies and strategies for healthcare organizations [16]. Consequently, many countries have deployed m-health services to combat the pandemic, and this practice is being followed in the post-pandemic era. This deployment of technology in the health sector has posed various benefits as m-health applications are widely available, cost-effective, and can aid a healthy lifestyle [17]. Fig. 1 illustrates the workflow of m-health applications, from data collection to guidance for medical professionals.

The adoption of m-health is crucial for the advancement of healthcare in developing countries [18]. However, people are resistant to adopting m-health practices for various reasons, including a lack of trust in the m-health applications and a lack of understanding of m-health implications. The knowledge regarding what could influence the use of m-health may lead to the selection of effective m-health implementation strategies [19, 20].

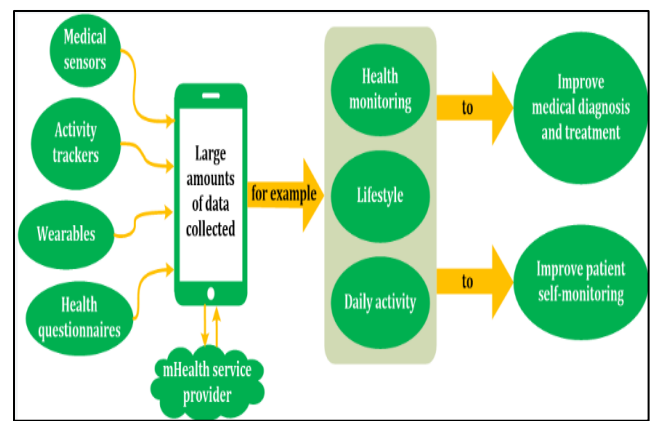


Fig. 1. Conceptual block diagram of m-health app functionality

Various studies have identified challenges that hinder the adoption of m-health application systems in developing countries. It has been argued by [6] that global and/or local acceptance of an interoperability culture, forwarding the referred patient's records, an intelligent and connected healthcare network, and a lack of data security hinder the proliferation of m-health applications. Moreover, in 2023, a research study concluded that the effectiveness, usability, and quality of m-health applications constitute a significant setback to the growing adoption of m-health applications [17]. The lack of software quality and the lack of m-health training for healthcare professionals are leading challenges that obstruct the adoption of ICT in healthcare [14]. Furthermore, the devices and equipment required for m-health adoption are expensive and not readily available in developing countries, thus private ambulatory clinics and smaller public facilities lag in technology adoption [21-23].

Another study [24] highlights that deficiencies in the usability of the m-health applications prevent people from adopting m-health. Privacy, security, and lack of trust in the m-health applications are also listed as prime challenges in the m-health progression [25]. Christopher et al. have reported that medical equipment and applications are not only linked to security but also to innovative design, cost-effectiveness and the strict regulations by the governing bodies [26]. The implementation of support and training programs aligned with the availability and workload of the professionals is a crucial point of consideration in improving the adoption of m-health [27]. The lack of accessibility is another significant barrier to the adoption of m-health applications [28]. The low cultural design, non-user-friendly interface, lack of technical sophistication, scalability, and design may inhibit the adoption of m-health applications [29].

Lack of management and sharing of electronic records leads to the decline of m-health in developing countries [30]. Lack of adequate electricity supply, low education level of technical staff, lack of ICT

infrastructure, and unsustainable funding are obstacles to integrating ICT into the healthcare domain [31, 32]. The lack of appreciation by the government, along with issues such as Internet connectivity, cost, and maintenance, blocks the way to the success of m-health [33, 34]. A study conducted by Nishtar, et al. [22] has highlighted various challenges, such as lack of knowledge, lack of research, lack of resources, limitation of transparency & accountability, government health policy vacillation, and underinvestment in health due to economic decline,

which are adversely affecting the adoption of m-health systems. It has been claimed by Anwar, et al. [18] that poverty, inadequate resource allocation, inefficient access to hardware, inadequate infrastructure, and lack of technical sophistication are some of the significant barriers to the adoption of ICT in developing countries. The list of m-health adoption challenges gathered by the in-depth literature review is presented in Table 1.

Table 1
Challenges of m-health

Sr. No.	Challenges	Ref	Sr. No.	Challenges	Ref
1	Complexity	[35]	26	Lack of research	[23]
2	Confidentiality	[35]	27	Lack of resources	[23]
3	Cost barriers	[18]	28	Lack of skilled human resources	[18]
4	Low cultural acceptance	Experts' opinion	29	Lack of a sound national strategy	[36]
5	Lack of Internet availability		30	Lack of technical sophistication	[18]
6	Lack of equity		31	Lack of trust	[37, 38]
7	Lack of regular training	[39]	32	Low literacy of health terms	[40]
8	Lack of appreciation by the government	[14]	33	Lack of multilingual support for m-health	[36]
9	Lack of appropriate equipment	[14, 39]	34	Natural calamities	[41]
10	Lack of bandwidth	[37]	35	Lack of m-health software quality	[37]
11	Lack of customization	[40]	36	Preference given to traditional ways	[42]
12	Lack of m-health assessment and evaluation process	[36]	37	Privacy and Security	[35, 43]
13	Lack of medical professionals' readiness	[18]	38	Provision of computer hardware and software	[18]
14	Lack of an m-health action plan	[44]	39	Lack of quality care	[35]
15	Lack of m-health adoption frameworks	[45]	40	Lack of quality service	[35]
16	Lack of m-health infrastructure	[18]	41	Dissatisfaction by the patient	[35]
17	Lack of m-health strategies	[46]	42	Dissatisfaction by the physician	[35]
18	Lack of m-learning	[36]	43	Scalability	Experts' opinion
19	Lack of government policies for health improvement	[23]	44	Underinvestment in health	
20	Lack of government-supported e-health sites	[36]	45	Time barriers	
21	Lack of interactive communication with users	[40]	46	Strict Federal Standards (HIPAA) and Accreditation Standards (JCAHO)	[35]
22	Lack of interoperability	[40][47]	47	Unsustainable funding	[34]
23	Lack of knowledge	[23][21]	48	Usability of m-health applications	[48]
24	Lack of maintenance culture	[34]	49	Lack of user-friendly design	[45]
25	Lack of multimedia in m-health applications	[40]			

Numerous studies have been conducted to address the diverse challenges confronted by the adoption of m-health systems. However, a comprehensive study encompassing the maximum number of challenges is

still required, as well as there is a dire need for prioritization of the challenges to confront the hindrances in the adoption of m-health radically [39]. Therefore, this study intends to identify the challenges

that are crucial for the adoption of m-health systems. Further, the identified challenges need to be ranked to propose a hierarchical model following the categorization of the identified challenges into respective dimensions. Finally, this study concludes by proposing a hierarchical model of adoption challenges.

The current study distinguishes itself from the previous research studies by deploying a comprehensive and data-driven approach to the adoption of m-health. The study has consolidated an exhaustive list of 49 challenges, followed by empirical validation through quantitative analysis, and their ranking according to their significance. The significance has been derived by using statistical tools, enabling the development of a hierarchical model that offers theoretical and practical applicability.

To achieve the objectives of this study, the following Research Questions (RQ) have been devised;

RQ1. What are the prevailing challenges of m-health adoption?

RQ2. What are the challenges that are crucial for the adoption of m-health systems?

RQ3. How could these challenges be ranked according to their priority?

RQ4. How could the identified challenges be categorized?

The paper is organized as follows: Section 2 delineates the research methodology adopted to accomplish the objective of this study. Section 3 discusses the results. The process of the proposition hierarchical model for m-health issues has been outlined in Section 4. It includes prioritization of the extracted crucial issues, categorization of the prioritized issues, and devising the hierarchical model for m-health adoption issues. The implications of the work for both academic and research purposes are highlighted in Section 5. Finally, the conclusion of this research has been elaborated in Section 6.

2. Research Methodology

The selection of sound research methodology is essential to conduct good research work. The quantitative mode of research has been selected to perform this work. The survey questionnaire tool has been deployed to collect data from the selected population. The collected data has been analysed by SPSS, followed by the necessary pre-processing of the collected data. Different statistical tools have been applied to the data obtained from the survey to propose a hierarchical model following the categorization of extracted challenges in various dimensions. The detailed methodology is illustrated in Fig. 2.

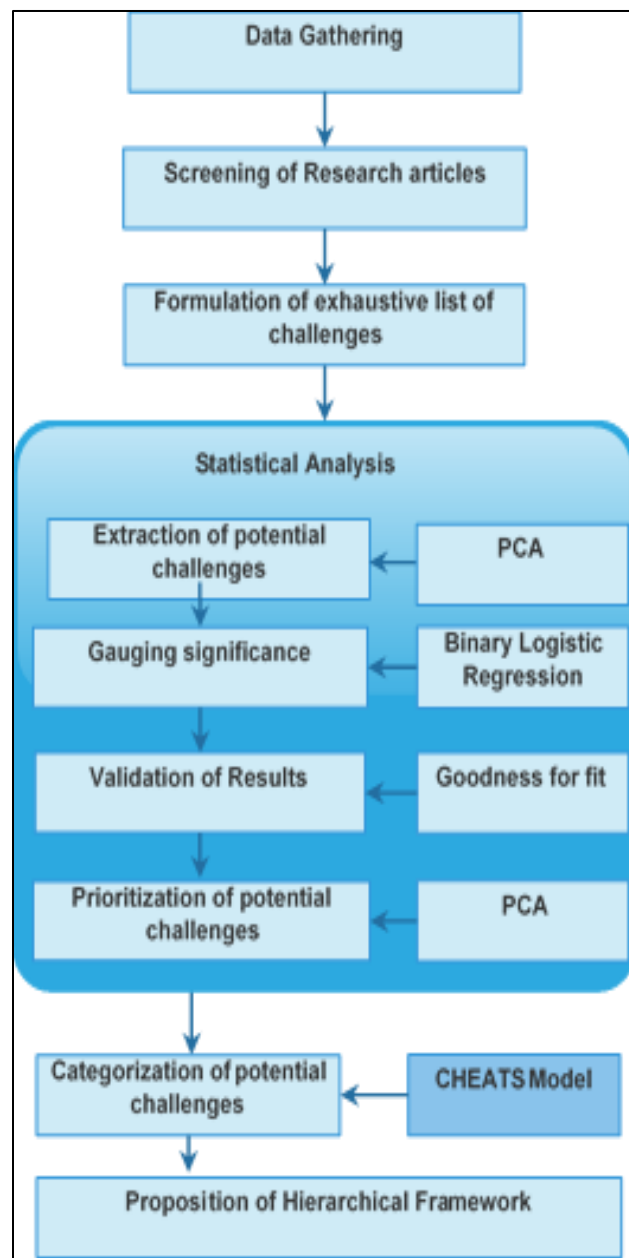


Fig. 2. Flow of research

2.1 Sample

One hundred and eighty-five survey questionnaires have been distributed among targeted respondents, out of which one hundred and sixty-seven responses have been received at the rate of 90%. The selected respondents belong to domains of IT and medical, including academia, m-health research, paramedics, medical practitioners, and patients.

These respondents are associated with different higher education institutions, teaching hospitals, and software development SMEs located in various urban and rural localities of Pakistan. The inclusion of a population from the medical domain aims to provide in-depth insights into the challenges faced by medical practitioners. Meanwhile, experts from academia and research have focused on achieving a state-of-the-art opinion on the challenges associated with adopting m-health systems. The demographic profile of the respondents is illustrated in Table 2.

Table 2

Demographic profile of the respondents

Description	Category	Number of respondents n= 167
Occupation	Researchers	27
	Pharmacists	25
	Patients	33
	Medical Practitioners	26
	Academicians	19
	Software developers	14
	Paramedics	23
Gender	Male	89
	Female	78
Proficiency in the Internet	Novice	17
	Intermediate	61
	Expert	89
Internet usage	<1 year	37
	1-2 years	25
	2-3 years	27
	>3 years	78
	1-3 years	39
Domain experience	4-6 years	42
	7-9 years	66
	10 or above	20

2.2 Data Gathering

Data collection is a tactical and complicated procedure that has been exercised during this research process. Collection of data is performed in an appropriate format to match the requirements. An extensive literature review has been conducted to gather the scattered challenges from the literature (as illustrated in Table 1). Different search strings have been formulated to identify the variety of challenges from diverse databases (as mentioned in Table 3). More than 60 publications from various renowned journals, case studies, and articles are analysed in depth to identify key m-health adoption issues. Moreover, incorporating expert opinion adds a few challenges, leading to an exhaustive set of crucial challenges.

2.2.1 Search String

Potential research articles have been identified by executing various combinations of search strings, including identified keywords. This activity has assisted in identifying diverse issues without any specified perspective. Studies with at least one keyword in the title, focusing on issues, challenges,

and factors that hinder electronic-healthcare adoption, have been selected. The following search strings have been articulated for automated search on targeted databases.

((critical OR crucial OR important OR severe OR vital) AND (issues OR challenges OR barriers OR obstacles) AND (for) AND (adoption OR implementation OR acceptance) AND (m OR e OR electronic OR web-based) AND (health OR healthcare OR health informatics OR paramedic))

2.2.2 Databases

The targeted databases selected for the identification of maximum issues that hinder the adoption of m-health are depicted in Table 3.

Table 3

Targeted databases for automated search

Google Scholars	IGI Global
IEEE XPLORE	Springer Link
ACM	Elsevier
Pro-quest	Emerald Insight

2.2.3 Survey Questionnaire

The open-ended survey questionnaire/instrument has been formulated to distribute among the targeted population of the study. An open-ended survey is considered less biased as the respondents have freedom to answer [49-51]. The respondents have been requested to rate each issue on a scale of 1 (Not Significant) to 5 (Most Significant). Furthermore, the respondents have also been requested to include any challenge(s) at the end of the list, which could be crucial and missed in the instrument. Before administering the survey, a pilot study is also conducted to validate the identified challenges and to gauge the validity of the survey instrument. Suggestions and guidelines obtained from the experts who participated in the pilot study are incorporated accordingly.

3. Results

The data obtained from the survey has been analysed utilizing statistical tools like Cronbach's Alpha and Principal Component Analysis (PCA). Cronbach's Alpha is implemented to measure the reliability and internal consistency of the survey instrument, while PCA has been implemented to extract the crucial issues. The extracted challenges have been prioritized by adopting predictive models, i.e., binary logistic regression. The m-health adoption challenges have been arranged by their importance.

3.1 Reliability of the Survey Instrument

Cronbach's Alpha has been deployed to validate and gauge the reliability of the survey instrument. It measures the internal consistency of the survey instrument [52, 53]. The acceptable range of alpha value is from 0.7 to 0.95. The low value of alpha indicates poor relevance that leads to poor quality of the survey instrument [54-56]. The value of Cronbach's Alpha obtained for this study is 0.79, which describes the reliability of the survey instrument. The value of alpha close to 1 shows excellent internal consistency, and a value less than 0.5 shows the unreliability of the survey instrument [57].

3.2 Extracting Potential Challenges

Principal Component Analysis (PCA) is employed to extract the crucial challenges of m-health adoption from the exhaustive list. This technique is being excessively used to filter out the required dataset from complex data. The extraction of critical issues is globally used in social science, applied science, neuroscience, and computer graphics. It is accepted as a method of interpreting self-explanatory questionnaires [58, 59]. Many variations in the technique of factor analysis, such as centroid and Principal Component Analysis, could easily be perceived from the existing literature [60, 61]. PCA has been applied to 49 identified challenges, from which 17 have been regarded as vital after computing their mean values based on data collected from respondents during the survey.

A Scree plot is employed to visually assess which item or factor (m-health adoption issues in this case) explicates most of the variability of the dataset. Eigenvalues associated with each item are calculated and have been displayed in descending order along the y-axis, whereas the number of items is shown along the x-axis. The scree plot of m-health adoption issues is given in Fig. 3.

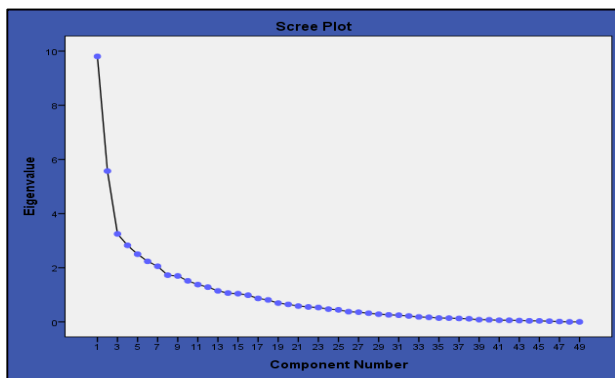


Fig. 3. Scree plot of m-health adoption challenges

The scree plot (Fig. 3) shows that 17 of those issues account for most of the variability, as the line starts to straighten after item number 17 on the x-axis. The

extracted challenges, shown in Table 4, are crucial according to the opinion of the targeted population of the study. The remaining issues contribute minimally to variance and are therefore deprioritized.

Table 4

Extracted challenges crucial for m-health adoption

No.	Challenges	Mean
1.	Lack of m-health software quality	4.10
2.	Lack of medical professionals' readiness	3.88
3.	Lack of Internet availability	3.84
4.	Lack of quality care	3.81
5.	Lack of trust	3.81
6.	Lack of m-health infrastructure	3.75
7.	Lack of resources	3.72
8.	Privacy and security	3.71
9.	Lack of regular training	3.69
10.	Lack of quality service	3.69
11.	Lack of an m-health action plan	3.69
12.	Lack of m-health adoption frameworks	3.65
13.	Lack of skilled human resources	3.62
14.	Scalability	3.59
15.	Lack of multilingual support for m-health	3.56
16.	Lack of user-friendly design	3.48
17.	Low cultural acceptance	3.44

Binary logistic regression has been deployed to gauge the significance of the challenges extracted by PCA, as illustrated in Table 5. It is a type of regression analysis that can be employed to analyse categorical variables. Logistic regression could be considered similar to multiple regression analysis, even though the dependent variable is categorical. It serves as a basis for defining the relationship between related variables [62]. Binary logistic regression is widely used in various fields, including machine learning, medicine, and social science. Regression models are the mainstay of predictive analytics. The focus lies on establishing a mathematical equation as a model to represent the interactions between the different variables under consideration [63].

If the p-value of the issue is less than 0.05, then the issue is considered significant. Significant describes the importance of the corresponding issue for the adoption of m-health. The p-values of the issues given in Table 5 are less than 0.05, which depicts the crucial nature of the extracted issues. Thus,

the results ascertain the consideration of the issues that are listed in Table 5.

Table 5

Significance of the Extracted Challenges

No	Challenges	Coefficient	SE Coefficient	P
		t	t	
1	Constant	-8	7.56	
1	Lack of m-health software quality	-0.228	0.249	0.000
2	Lack of medical professionals	0.115	0.228	0.000
3	Lack of Internet availability	-0.119	0.207	0.000
4	Lack of quality care	0.208	0.211	0.000
5	Lack of trust	0.372	0.207	0.000
6	Lack of m-health infrastructure	-0.045	0.237	0.000
7	Lack of resources	-0.071	0.197	0.000
8	Privacy and security	0.141	0.269	0.000
9	Lack of regular training	0.277	0.232	0.000
10	Lack of quality service	-0.095	0.224	0.001
11	Lack of an m-health action plan	0.216	0.224	0.001
12	Lack of m-health adoption frameworks	0.143	0.498	0.008
13	Lack of skilled human resources	0.210	1.003	0.009
14	Scalability	0.151	0.149	0.010
15	Lack of multilingual support	0.023	0.046	0.010
16	Lack of user-friendly design	0.045	0.0348	0.030
17	Low cultural acceptance	0.409	0.349	0.038

3.4 Goodness of Fit for Logistic Regression Model

The results of binary logistic regression are considered reliable if the goodness-of-fit test is achieved by the model. The conditions used to test the regression model, if it is good for the data gathered about m-health adoption challenges, are described below.

1. H_0 : Model is a good fit
 H_1 : Model is not a good fit
2. Level of significance $\alpha = 0.05$
Test statistics:
 - a. Deviance
 - b. Pearson
 - c. Hosmer-Lemeshow

3. Decision

The results of the goodness-of-fit test are given in Table 6. The P-value is greater than 0.05, hence the model is considered fit for the said tests.

Table 6

Goodness of Fit

Test	DF	Chi-Square	P-Value
Deviance	87	122.14	0.008
Pearson	87	98.55	0.187
Hosmer-Lemeshow	8	4.08	0.850

4. Proposition of the Model

This section outlines the process used to propose the hierarchical model for addressing the adoption issues of m-health systems in the country.

4.1 Prioritization of Challenges

The challenges that hinder the integration of ICT in healthcare in developing countries have been prioritized and ranked (as illustrated in Fig. 5) according to their severity, as concluded by PCA, which determines the contribution of each challenge towards a complete dataset. The arrangement of these extracted challenges is based on the proportion of each issue that hinders a complete dataset. The proportion of each challenge is given along with its respective cumulative values in Table 7. The most crucial challenge is ranked at level 1, and the least vital challenge is ranked at the lowest level (as in Fig. 5). Out of 49, only 17 challenges are marked as crucial (as illustrated in Table 7). In contrast, the contribution of the rest of the challenges is negligible.

Table 7

Prioritization of the m-health adoption issues

Ranks	Component	Total	Proportion	Cumulative
1	Lack of m-health Software Quality	9.804	20.008	20.008
2	Lack of medical professionals' readiness	5.569	11.365	31.373
3	Lack of Internet availability	3.248	6.628	38.001

4	Lack of quality care	2.825	5.765	43.766
5	Lack of trust	2.499	5.099	48.866
6	Lack of m-Health Infrastructure	2.233	4.557	53.423
7	Lack of resources	2.052	4.188	57.610
8	Privacy and security	1.724	3.518	61.128
9	Lack of regular training	1.696	3.461	64.589
10	Lack of quality service	1.514	3.090	67.679
11	Lack of an m-health action plan	1.376	2.808	70.487
12	Lack of m-health adoption frameworks	1.281	2.615	73.102
13	Lack of skilled human resources	1.144	2.334	75.436
14	Scalability	1.063	2.169	77.605
15	Lack of multilingual support for m-health	1.041	2.125	79.730
16	Lack of user-friendly design	.985	2.010	81.740
17	Low cultural acceptance	.864	1.764	83.504
Rest all			16.496	100

4.2 Classification of Crucial Challenges

The crucial challenges of m-health adoption have been categorized into four dimensions, followed by rigorous empirical investigation. These dimensions have been identified from the existing literature, as discussed by the CHEATS framework [64]. The identified dimensions are educational awareness, professional culture, technical support, and Supportive infrastructure. Extracted challenges have been categorized into respective dimensions based on the extensive literature review. The categorization of challenges into respective dimensions and the rationale behind the association of each of the

challenges into its particular dimension are discussed in Section 4.2 and are illustrated in Fig. 4.

4.2.1 Educational Awareness

All the issues related to educational matters are listed under the caption of ‘educational awareness’ [64, 65]. Expert’s categorized issues include a lack of skilled staff, inadequate training, and insufficient e-readiness among medical professionals, all of which fall under the dimension of educational awareness. According to the CHEATS model, trainers should be assessed during training sessions, and feedback from listeners should be used to evaluate the quality of training delivery. Thus, the issues associated with the educational needs of trainers and trainees have been included in this category.

4.2.2 Supportive Infrastructure

The variation in the administration of various health services could be grouped under the label of ‘supportive infrastructure’ due to the inclusion of ICTs [65]. The provision of resources is the duty of administration. Experts have suggested categorizing the following under this dimension: lack of action plan, lack of m-health adoption frameworks, lack of Internet availability, lack of m-health infrastructure, and lack of resources.

4.2.3 Technical Support

Experts have suggested categorizing challenges that occur due to the lack of technological innovations into the technical support dimension. The technical Support dimension lists the issues that relate to the frailties of the technology. The label technology encompasses all the issues that arise due to the inefficient usage of technological advancements. The challenges, such as the lack of software quality of m-health applications, user-friendly design of m-health applications, lack of multilingual support, scalability, quality of service, privacy, and security, are suitable for this category.

4.2.4 Professional Culture

Professional Culture is the first and foremost dimension elaborated in the CHEATS model. The inclusion criteria encompass issues related to patient healthcare activities, such as cultural differences between physicians and patients, which can adversely impact healthcare outcomes. Experts have categorized lack of quality of care, low cultural acceptance, and lack of trust into the professional culture dimensions as per the CHEATS model [64].

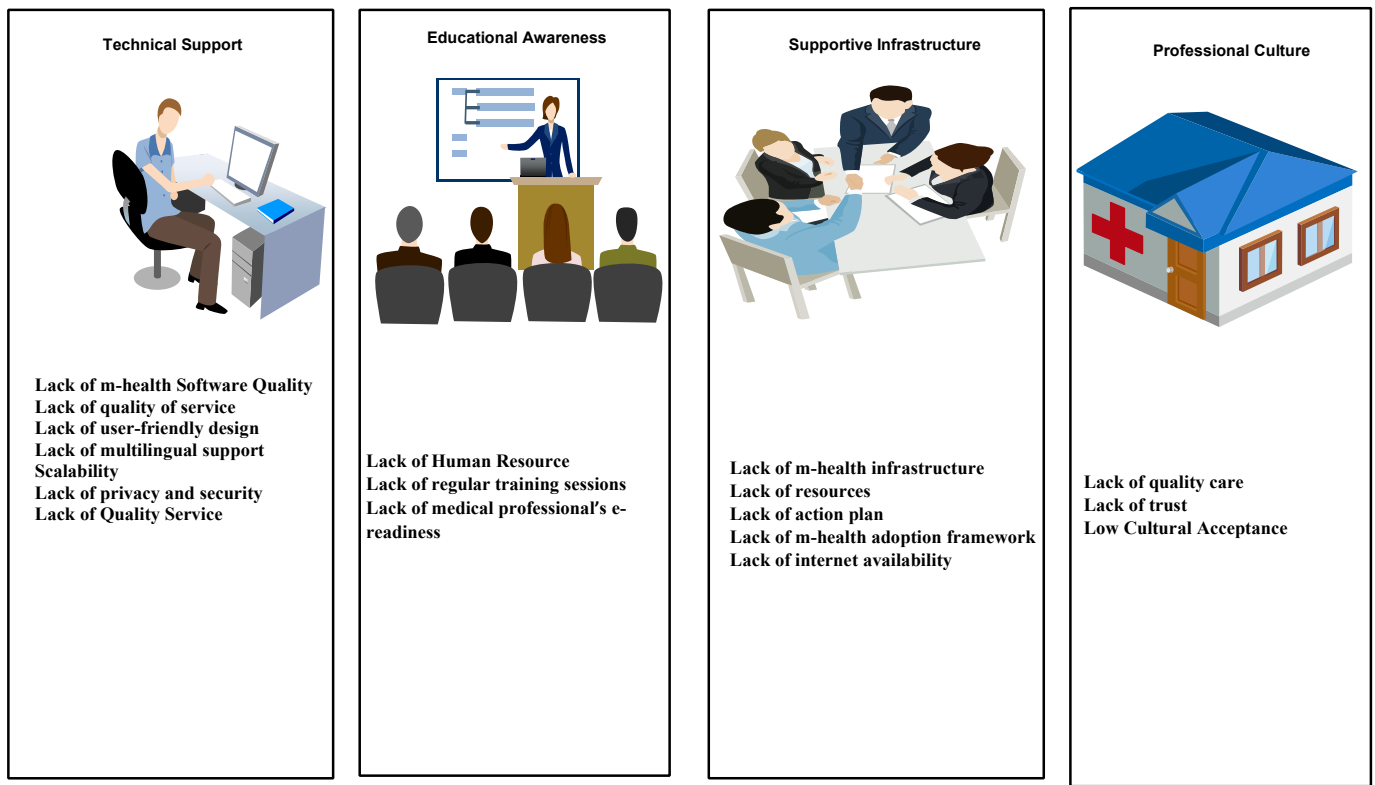


Fig. 4. Classification of the crucial challenges

4.3 Formulation of Hierarchical Mode

The hierarchical model of challenges of m-health adoption has been formulated as illustrated in Fig. 5, based on empirical investigation. Lack of proper m-health infrastructure, the readiness of medical professionals, lack of Internet availability, and lack of quality care have been revealed as the most crucial issues to achieve this paradigm shift. Lack of trust among ordinary users (patients in this case) is also a vital issue. This study highlights that a lack of steady power support is a critical issue, ranking sixth in priority for developing countries, particularly Pakistan, which has been grappling with the energy crisis for the past decade.

5. Implications for Theory and Practice

This work has significant implications for the adoption of m-health systems by providing a roadmap to the health department in devising its strategies for the promotion and adoption of m-health systems. Health policymakers and monitoring authorities can also benefit by addressing the identified crucial challenges that people face in adopting m-health systems, which are a need of society. Additionally, this work attracts doctors, researchers, and academicians aiming not only to provide solutions to the identified challenges but also to educate people to become competent users of m-health systems.

This study suggests that awareness and readiness of physicians and doctors could be developed and

maintained by regular training through the provision of appropriate devices and tools. This study further reveals that technical infrastructure, skills, and standards, together with evaluation and assessment, are pivotal for national m-health implementation. Moreover, healthcare providers should be allowed to take part in information system design, and the information system contents must be added according to their requirements.

6. Discussion

To address RQ1, the identification of challenges encountered during ICT integration in healthcare systems has been completed. An exhaustive list of forty-nine challenges has been articulated after intensive literature searching. Critical challenges are extracted from this exhaustive list by applying PCA, which leads to the answer of RQ2, and is delineated in Section 3.2 and Table 4. After extracting crucial challenges, these are prioritized according to their severity using a predictive model for a localized environment to address RQ3. This has been discussed in Section 4.1. Categorizing the prioritized challenges into diverse dimensions by utilizing the CHEATS model is achieved to tackle the task of RQ4. The categorization of challenges into respective dimensions, along with the rationale behind associating each challenge with its particular dimension, is described in Section 4.2 and elaborated in Fig. 4. Section 4.3 addresses RQ5, illustrating the structure in Fig. 5.

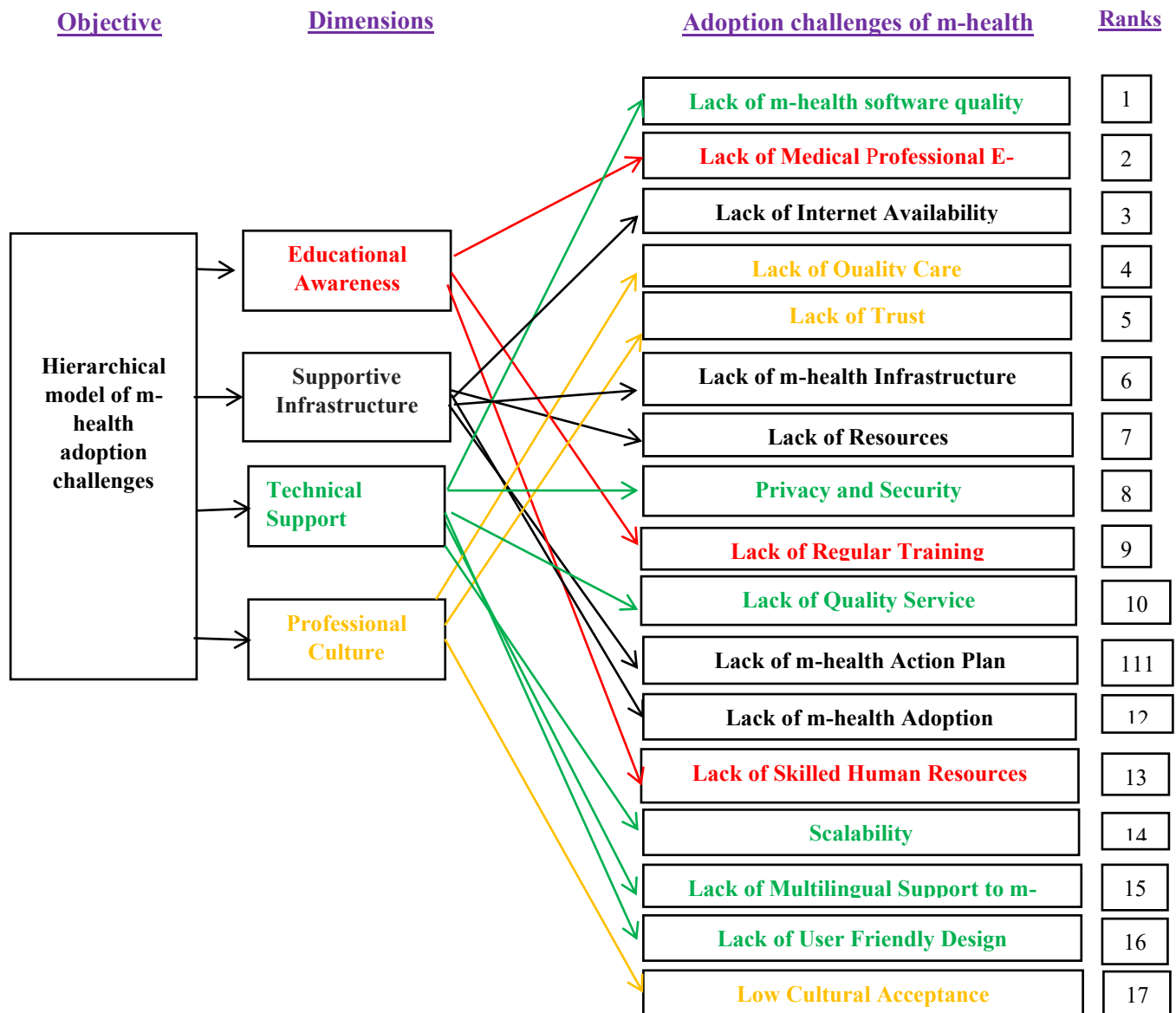


Fig. 5. Structure of the proposed hierarchical model

7. Limitations

The study has some limitations, such as respondents have been selected from one country, that is, Pakistan. Nonetheless, the study can be enhanced by selecting participants from other developing countries like India, Malaysia, Bangladesh, etc. Moreover, the study focuses only on four dimensions, including Educational Awareness, Supportive Infrastructure, Technical Support, and Professional Culture. Further investigation is recommended to identify other dimensions from the literature.

8. Conclusion

The integration of ICT in healthcare informatics is a matter of interest, especially for developing nations. M-health has become the mainstream future aspect due to its cost-effectiveness and ease of access, irrespective of time and place. It not only helps to meet the social distancing conditions required to avoid

spreading pandemics like the coronavirus, but also provides healthcare at home even in remote areas. Developing countries, such as Pakistan, which have limited resources in terms of finances and technology, face various challenges in deploying m-health systems. Moreover, the lack of efficient, secure, and effective national policy also significantly inhibits the adoption of m-health. State-of-the-art literature has been explored deeply to identify and organize the scattered challenges faced in the adoption of m-health systems. Over 60 research articles published in well-renowned journals and conferences have been analysed to identify forty-nine issues. Empirical investigations have been carried out with the targeted population to prioritize the identified challenges according to their importance and severity. Out of these, seventeen challenges have been identified as most crucial based on results from various statistical tests, including Cronbach's Alpha, PCA, and

predictive analysis using a logistic regression model. Then these issues are ranked and categorized into four dimensions, including educational awareness, supportive infrastructure, technical support, and professional culture based on the CHEATS model. This study reveals that lack of m-health infrastructure, readiness of medical professionals, lack of Internet availability, lack of quality care, lack of trust, and lack of m-health software quality have emerged as the most crucial issues in order to accomplish this digital paradigm shift towards the m-health propagation.

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10. References

- [1] E. T. Megbowon and O. O. J. F. i. P. H. David, "Information and communication technology development and health gap nexus in Africa," vol. 11, p. 1145564, 2023.
- [2] D. Silber, The case for eHealth. European Institute of Public Administration, Maastricht, The Netherlands, 2003.
- [3] T. H. Tebeje and J. Klein, "Applications of e-health to support person-centered health care at the time of the COVID-19 pandemic," *Telemedicine and e-health*, vol. 27, no. 2, pp. 150-158, 2021.
- [4] F. Bukachi and N. Pakenham-Walsh, "Information technology for health in developing countries," *Chest*, vol. 132, no. 5, pp. 1624-1630, 2007.
- [5] A. M. Rahmani et al., "Exploiting smart e-Health gateways at the edge of healthcare Internet-of-Things: A fog computing approach," *Future Generation Computer Systems*, vol. 78, pp. 641-658, 2018.
- [6] R. P. Singh, M. Javaid, A. Haleem, R. Vaishya, and S. Bahl, "Significance of Health Information Technology (HIT) in context to COVID-19 pandemic: Potential roles and challenges," *Journal of Industrial Integration and Management*, vol. 5, no. 4, 2020.
- [7] D. Hallberg and N. J. H. i. r. Salimi, "Qualitative and Quantitative Analysis of Definitions of e-Health and m-Health," vol. 26, no. 2, pp. 119-128, 2020.
- [8] S. Iqbal et al., "Real-time-based E-health systems: Design and implementation of a lightweight key management protocol for securing sensitive information of patients," *Health and Technology*, vol. 9, no. 2, pp. 93-111, 2019.
- [9] V. Vijayakumar, M. Priyan, G. Ushadevi, R. Varatharajan, G. Manogaran, and P. V. Tarare, "E-health cloud security using timing-enabled proxy re-encryption," *Mobile Networks and Applications*, vol. 24, no. 3, pp. 1034-1045, 2019.
- [10] A. Almanthari, S. Maulina, and S. Bruce, "Secondary school mathematics teachers' views on E-learning implementation barriers during the COVID-19 pandemic: the case of Indonesia," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 16, no. 7, p. em1860, 2020.
- [11] M. Staffa et al., "An OpenNCP-based Solution for Secure eHealth Data Exchange," *Journal of Network and Computer Applications*, vol. 116, pp. 65-85, 2018.
- [12] A. Papa, M. Mital, P. Pisano, and M. Del Giudice, "E-health and wellbeing monitoring using smart healthcare devices: An empirical investigation," *Technological Forecasting and Social Change*, 2018.
- [13] B. Singh et al., "A systematic umbrella review and meta-meta-analysis of eHealth and mHealth interventions for improving lifestyle behaviours," vol. 7, no. 1, p. 179, 2024.
- [14] M. Malik, N. M. Larik, and S. A. Khan, "Use of information technology by practising clinicians in Pakistan: a questionnaire survey," *Journal of Health Informatics in Developing Countries*, vol. 2, no. 2, 2008.
- [15] P. D'Urso, L. De Giovanni, and P. Spagnoletti, "A fuzzy taxonomy for e-Health projects," *International Journal of Machine Learning and Cybernetics*, vol. 4, no. 5, pp. 487-504, 2013.
- [16] M. Kovačić, M. Mutavdžija, and K. Buntak, "E-health application, implementation and challenges: a literature review," *Business Systems Research: International journal of the Society for Advancing Innovation and Research in Economy*, vol. 13, no. 1, pp. 1-18, 2022.
- [17] A. Deniz-Garcia et al., "Quality, usability, and effectiveness of mHealth apps and the role of artificial intelligence: current scenario and challenges," vol. 25, p. e44030, 2023.
- [18] F. Anwar, A. Shamim, and S. Khan, "Barriers in adoption of health information technology

- in developing societies," *Int J Adv Comput Sci Appl*, vol. 2, no. 8, pp. 40-5, 2011.
- [19] A. J. de Veer, J. M. Peeters, A. E. Brabers, F. G. Schellevis, J. J. J. Rademakers, and A. L. Francke, "Determinants of the intention to use e-Health by community dwelling older people," *BMC health services research*, vol. 15, no. 1, p. 103, 2015.
- [20] V. H. Castillo, A. I. Martínez-García, and J. Pulido, "A knowledge-based taxonomy of critical factors for adopting electronic health record systems by physicians: a systematic literature review," *BMC medical informatics and decision making*, vol. 10, no. 1, p. 60, 2010.
- [21] S. Nishtar and A. B. Mehboob, "Pakistan prepares to abolish Ministry of Health," *The Lancet*, vol. 378, no. 9792, pp. 648-649, 2011.
- [22] E. Mbunge, "Integrating emerging technologies into COVID-19 contact tracing: Opportunities, challenges and pitfalls," *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, vol. 14, no. 6, pp. 1631-1636, 2020.
- [23] S. Nishtar et al., "Pakistan's health system: performance and prospects after the 18th Constitutional Amendment," *The Lancet*, vol. 381, no. 9884, pp. 2193-2206, 2013.
- [24] P. Svensson, S. Lin, and L. H. J. I. i. M. U. Iwaya, "Usability and Accessibility in mHealth Stroke Apps: An Empirical Assessment," p. 101616, 2025.
- [25] C.-K. Kao, A. Moawad, and A. Bhargava, "Mobile health apps: Current state, barriers, and future directions," in *The Digital Doctor*: Elsevier, 2025, pp. 53-67.
- [26] C. Adlung, N. van der Kooij, J. C. Diehl, S. J. H. Hinrichs-Krapels, and Technology, "Existing and emerging frameworks for the adoption and diffusion of medical devices and equipment in low-resource settings: a scoping review," pp. 1-25, 2025.
- [27] M. Delvallée et al., "Barriers and Facilitators in Implementing a Telemonitoring Application for Patients With Chronic Kidney Disease and Health Professionals: Ancillary Implementation Study of the NeLLY (New Health e-Link in the Lyon Region) Stepped-Wedge Randomized Controlled Trial," vol. 13, no. 1, p. e50014, 2025.
- [28] E. K. Ameyaw, P. A. Amoah, A. A. Asiamah, and P. J. B. o. Agbadi, "mHealth knowledge and usage in maternal healthcare delivery: perspectives and experiences of healthcare practitioners in Ghana," vol. 15, no. 1, p. e092746, 2025.
- [29] H. Ramdowar, K. K. Khedo, and N. J. U. A. i. t. I. S. Chooramun, "A comprehensive review of mobile user interfaces in mHealth applications for elderly and the related ageing barriers," vol. 23, no. 4, pp. 1613-1629, 2024.
- [30] D. M. Mugo and D. Nzuki, "Determinants of electronic health in developing countries," 2014.
- [31] A. Nkrumah Gordon and R. Ebo Hinson, "Towards a sustainable framework for computer based health information systems (CHIS) for least developed countries (LDCs)," *International journal of health care quality assurance*, vol. 20, no. 6, pp. 532-544, 2007.
- [32] J. K. Rotich et al., "Installing and implementing a computer-based patient record system in sub-Saharan Africa: the Mosoriot Medical Record System," *Journal of the American Medical Informatics Association*, vol. 10, no. 4, pp. 295-303, 2003.
- [33] P. Idowu, D. Cornford, and L. Bastin, "Health informatics deployment in Nigeria," *Journal of Health Informatics in Developing Countries*, vol. 2, no. 1, 2008.
- [34] M. A. Malik and H. R. Khan, "Understanding the implementation of an electronic hospital information system in a developing country: a case study from Pakistan," in *Proceedings of the Third Australasian Workshop on Health Informatics and Knowledge Management-Volume 97*, 2009, pp. 31-36.
- [35] N. Menachemi, D. E. Burke, and D. J. Ayers, "Factors affecting the adoption of telemedicine—a multiple adopter perspective," *Journal of medical systems*, vol. 28, no. 6, pp. 617-632, 2004.
- [36] W. H. Organization, *World health statistics 2016: monitoring health for the SDGs sustainable development goals*. World Health Organization, 2016.
- [37] S. Farid, R. Ahmad, and M. Alam, "A hierarchical model for e-learning implementation challenges using AHP," *Malaysian Journal of Computer Science*, vol. 28, no. 3, pp. 166-188, 2015.

- [38] G. Fox and R. Connolly, "Mobile health technology adoption across generations: Narrowing the digital divide," *Information Systems Journal*, vol. 28, no. 6, pp. 995-1019, 2018.
- [39] Q. A. Qureshi, N. A. Qureshi, M. Z. Khan, A. Nawaz, and B. Shah, "Issues and Prospects of e-health in Pakistan," *Mediterranean Journal of Medical Sciences*, vol. 1, no. 1, 2014.
- [40] G. L. Kreps and L. Neuhauser, "New directions in eHealth communication: opportunities and challenges," *Patient education and counseling*, vol. 78, no. 3, pp. 329-336, 2010.
- [41] J. Khan and A. Khan, "Incidence of dengue in 2013: dengue outbreak in District Swat, Khyber Pakhtunkhwa, Pakistan," *Inter J of Fauna and Biolo Stud*, vol. 2, no. 1, pp. 1-7, 2015.
- [42] D. Flynn, P. Gregory, H. Makki, and M. Gabbay, "Expectations and experiences of eHealth in primary care: a qualitative practice-based investigation," *International journal of medical informatics*, vol. 78, no. 9, pp. 588-604, 2009.
- [43] N. Archer, C. Lokker, M. Ghasemaghaei, and D. DiLiberto, "eHealth Implementation Issues in Low-Resource Countries: Model, Survey, and Analysis of User Experience," *Journal of Medical Internet Research*, vol. 23, no. 6, p. e23715, 2021.
- [44] W. L. Currie and J. J. Seddon, "A cross-national analysis of eHealth in the European Union: Some policy and research directions," *Information & Management*, vol. 51, no. 6, pp. 783-797, 2014.
- [45] M. Rezai-Rad, R. Vaezi, and F. Nattagh, "E-health readiness assessment framework in Iran," *Iranian journal of public health*, vol. 41, no. 10, p. 43, 2012.
- [46] M. E. Kruk, M. Myers, S. T. Varpilah, and B. T. Dahn, "What is a resilient health system? Lessons from Ebola," *The Lancet*, vol. 385, no. 9980, pp. 1910-1912, 2015.
- [47] D. G. Katehakis and A. Kouroubali, "A Framework for eHealth Interoperability Management," *Journal of Strategic Innovation and Sustainability*, vol. 14, no. 5, pp. 51-61, 2019.
- [48] K. MacLure and D. Stewart, "A qualitative case study of ehealth and digital literacy experiences of pharmacy staff," *Research in Social and Administrative Pharmacy*, vol. 14, no. 6, pp. 555-563, 2018.
- [49] S. Farid, R. Ahmad, M. Alam, A. Akbar, and V. Chang, "A Sustainable Quality Assessment Model for the Information Delivery in E-learning Systems," *Information Discovery & Delivery*, vol. 46, no. 1, 2018.
- [50] S. Farid, R. Ahmad, and M. Alam, "A Hierarchical Model for E-Learning Implementation Challenges using AHP," *Malaysian Journal of Computer Science*, vol. 28, no. 3, 2015.
- [51] F. Hasson, S. Keeney, and H. McKenna, "Research guidelines for the Delphi survey technique," *Journal of advanced nursing*, vol. 32, no. 4, pp. 1008-1015, 2000.
- [52] M. Tavakol, M. A. Mohagheghi, and R. Dennick, "Assessing the skills of surgical residents using simulation," *Journal of surgical education*, vol. 65, no. 2, pp. 77-83, 2008.
- [53] J. M. Cortina, "What is coefficient alpha? An examination of theory and applications," *Journal of applied psychology*, vol. 78, no. 1, p. 98, 1993.
- [54] J. M. Bland and D. G. Altman, "Statistics notes: Cronbach's alpha," *Bmj*, vol. 314, no. 7080, p. 572, 1997.
- [55] J. C. Nunnally and I. Bernstein, "Validity," *Psychometric theory*, pp. 99-132, 1994.
- [56] R. F. DeVellis, *Scale development: Theory and applications*. Sage publications, 2016.
- [57] D. George and M. Mallery, "Using SPSS for Windows step by step: a simple guide and reference," 2003.
- [58] J. Shlens, "A tutorial on principal component analysis," *arXiv preprint arXiv:1404.1100*, 2014.
- [59] B. Williams, A. Onsman, and T. Brown, "Exploratory factor analysis: A five-step guide for novices," *Australasian Journal of Paramedicine*, vol. 8, no. 3, 2010.
- [60] A. Vizcaíno, F. García, J. C. Villar, M. Piattini, and J. Portillo, "Applying Q-methodology to analyse the success factors in GSD," *Information and Software Technology*, vol. 55, no. 7, pp. 1200-1211, 2013.
- [61] M. C. Tam and V. R. Tummala, "An application of the AHP in vendor selection of

a telecommunications system," *Omega*, vol. 29, no. 2, pp. 171-182, 2001.

- [62] M. Tranmer and M. Elliot, "Binary logistic regression," *Cathie Marsh for census and survey research*, paper, vol. 20, 2008.
- [63] O. Cokluk, "Logistic Regression: Concept and Application," *Educational Sciences: Theory and Practice*, vol. 10, no. 3, pp. 1397-1407, 2010.
- [64] N. T. Shaw, "'CHEATS': a generic information communication technology (ICT) evaluation framework," *Computers in biology and medicine*, vol. 32, no. 3, pp. 209-220, 2002.
- [65] N. Nijland, "Grounding eHealth: towards a holistic framework for sustainable eHealth technologies," 2011.